

Strategies for biological confinement of genetically engineered plants

Henry Daniell

University of Central Florida, Dept. Molecular Biology & Microbiology, Biomolecular Science
Building #20, Room 336, Orlando FL 32816-2364, U.S.A. daniell@mail.ucf.edu.

Summary

The potential of genetically modified (GM) crops to transfer foreign genes through pollen or seeds has been recognized as an environmental concern. To date, most approaches with potential for controlling gene flow among crops and weeds have focused on maternal inheritance, reversible or irreversible male sterility (genic or cytoplasmic) and seed sterility (terminator technology, recoverable block of function, repressive seed lethal confinement). Male sterility has been already commercially exploited in Canola. It is very effective in preventing out-crossing from GM crop to weeds or related non-GM crops. Maternal inheritance is a promising approach for transgene containment with added advantages of high levels of transgene expression, rapid multigene engineering, lack of position effect, gene silencing and pleiotropic effects. Currently, chloroplast genetic engineering has been enabled in tobacco, a non-food/feed crop as a bioreactor for production of biopharmaceuticals or biopolymers. Chloroplast transformation has been enabled in several major GM crops, including cotton and soybean. Chloroplast transgenic carrot plants withstand salt concentrations that only halophytes could tolerate. Extension of chloroplast genetic engineering technology to other useful crops will depend on the availability of the plastid genome sequences and the ability to regenerate transgenic events. However, confinement of pollen-mediated spread of transgenes (via maternal inheritance or male sterility) does not address spread of transgenes via seeds. Most seed sterility systems are still under development and are affected by gene silencing, recombination & rearrangement of tightly linked transgenes or incomplete induction of repressors that function reliably at a given time.

Sterile triploids, unisexual plants lacking mates, cleistogamy (fertilization in closed flowers), apomixis (asexually produced seeds), absence of transgenes from seeds and pollen (excision of transgenes before reproduction), artificially induction of transgene expression on demand, cross-incompatibility, chromosomal locations in allopolyploids, fitness reduction in transgenic crop-wild progeny or reducing exposure to transgenic traits are other options available for bioconfinement of transgenes. However, most of these techniques are in very early stages of development and considerable investment / research is needed to develop the technologies outlined above. This presentation will focus on the use of various strategies for transgene containment, their advantages/disadvantages and summarize the National Research Council report (2004) on biological confinement of genetically engineered organisms (plants). Because no single strategy will be broadly applicable to all crop species, a combination of more than one approach might prove most effective for engineering failsafe mechanisms for the next generation of genetically modified crops. Until the environmental impact of novel genes on indigenous crops and weeds is thoroughly investigated, practical and regulatory considerations might require the adoption of gene containment approaches for future generations of GM crops.